

Remarks

Claims 1-6 were previously pending in the subject application. By this Amendment, claims 1, 5 and 6 have been amended and new claims 7-9 have been added. Accordingly, claims 1-9 remain before the Examiner for consideration. In view of the remarks and amendments set forth herein, favorable consideration of the claims now presented is earnestly solicited.

In order to expedite prosecution, the claims have now been amended to lend greater specificity and clarity to the claimed subject matter. These amendments are made solely for the purpose of expediting prosecution and should not be taken to indicate the applicants' agreement with, or acquiescence in, the rejections of record.

Claims 1-4 have been rejected under 35 U.S.C. §102(b) as being anticipated by Kita *et al.* (JP 10-112335). The applicants respectfully traverse this grounds for rejection because Kita *et al.* do not disclose or suggest the advantageous compositions of the current invention. Specifically, Kita *et al.* do not disclose a composition having the ratio of a fluorobenzene (FB) component to a carbonic acid ester (CE) component as claimed by the current applicants.

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The present invention is directed to a non-aqueous (i.e., organic) electrolyte composition for a secondary battery comprising i) a fluorobenzene component, and ii) a carbonic acid ester component for which cyclic carbonates, aliphatic carbonates, or a mixture thereof, can be used. The ratio of these components is unique to the current invention and is not within the ranges described by Kita *et al.* Unlike Kita *et al.*, who use less than 10% of the fluorobenzene component, the current invention exploits the surprising finding that a greater percentage of fluorobenzene is advantageous. In fact, as described in Example 5 of the subject application, a ratio as high as 50:50 FB:CE can be used. As a lower end to the range, claim 1 now recites an 11:1:88.9 FB:CE ratio. Support for this value can be found in, for example, Example 2 of the current application.

Also, in order to add greater specificity to the claim coverage, claim 7 has been added to reflect volumetric percentage ratios of 12.5:87.5 FB:CE to 50:50 FB:CE. Ratios of these quantities find support in Examples 5 and 6.

The Kita *et al.* reference does not disclose or suggest the use of an organic solvent containing large volumetric portions of fluoro-aromatic compounds. Rather, Kita *et al.* reference discloses an

electrolyte solution wherein FB is present in an amount of 0.1 to 10 weight part based on 100 weight part of a solvent of the electrolyte solution.

Please note that directly comparing the Kita *et al.* teachings to the current invention requires converting the FB and CE weight components into volumetric percentages. This exercise reveals high ratios of CE relative to FB. For example, using the disclosure in paragraph 16, the highest fluoro-aromatic volume percentage is 9.2%. Furthermore, utilizing the ratios given in paragraph 17, the highest fluoro-aromatic volume percentage of the solution is 9.5%. These percentages fall outside the ranges claimed by the current applicants.

It is a basic premise of the Patent Law that, to anticipate, a single reference must, within its four corners, disclose all of the limitations of the claimed invention. In *Lindemann v. American Hoist and Derrick Co.*, 221 USPQ 481 (Fed. Cir. 1984), the court stated:

Anticipation requires the presence in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim. *Connell v. Sears Roebuck and Co.*, 722 F.2d 1542, 220 USPQ 193 (Fed. Cir. 1983); *SSIH Equip. S.A. v. USITC*, 718 F.2d 365, 216 USPQ 678 (Fed. Cir. 1983). In deciding the issue of anticipation, the [examiner] must identify the elements of the claims, determine their meaning in light of the specification and prosecution history, and identify corresponding elements disclosed in the allegedly anticipating reference. *SSIH, supra*; *Kalman [v. Kimberly-Clarke]*, 713 F.2d 760, 218 USPQ 781 (Fed. Cir. 1983)] (emphasis added). 221 USPQ at 485.

In *Dewey & Almy Chem. Co. v. Mimex Co.*, Judge Learned Hand wrote:

No doctrine of the patent law is better established than that a prior patent . . . to be an anticipation must bear within its four corners adequate directions for the practice [of the subsequent invention] . . . if the earlier disclosure offers no more than a starting point . . . if it does not inform the art without more how to practice the new invention, it has not correspondingly enriched the store of common knowledge, and it is not an anticipation. 124 F.2d 986, 990; 52 USPQ 138 (2nd Cir. 1942).

When compared to the cited Kita *et al.* reference, the present invention has a different (non-overlapping) ratio of FB to CE. In other words, although the components in the composition are common to both inventions, the required amount of FB for the present invention is more than that of

the cited reference. Accordingly, the applicants respectfully request reconsideration and withdrawal of the rejection set forth under 35 U.S.C. 102(b) for claims 1-4.

Claims 1, 3 and 4 have been rejected under 35 U.S.C. §102(b) as being anticipated by Hamamoto *et al.* (JP 10-135294). The applicants respectfully call attention to the current applicants' foreign priority document, KR 99-26358, having a filing date of July 1, 1999 and PCT application PCT/KR99/00811 (designating the United States) having a filing date of December 24, 1999, from which this application takes its priority date. For the Examiner's convenience, an English translation of the foreign priority document, as originally filed in the Republic of Korea, is enclosed.

Please note that the publication date of the Hamamoto *et al.* reference was November 30, 1999. As the Hamamoto *et al.* publication date is not more than a year before the applicants' effective U.S. filing date, the applicants respectfully request reconsideration and withdrawal of the rejection set forth under 35 U.S.C. §102(b). Furthermore, in view of the applicants' July 1, 1999 priority date, which is before the publication date of the Hamamoto *et al.* reference, the applicants respectfully submit that the Hamamoto *et al.* reference is not available at all for making a prior art rejection.

Claims 5 and 6 have been rejected under 35 U.S.C. 103(a) as obvious over Kita *et al.* (JP 10-112335) or Hamamoto *et al.* (JP 10-135294) in view of the Merck Chemical Database. The applicant respectfully traverses this grounds for rejection because the cited references do not disclose or suggest a fluoro-aromatic volume ratio in the range disclosed in the present invention. Nor is there any motivation in the cited art to modify the teachings found in the cited references to arrive at the current invention.

As noted above, the applicants respectfully submit that the Hamamoto *et al.* reference is not available as prior art against the current invention. The Kita *et al.* reference taken alone or in combination with the Merck Chemical Database does not disclose or suggest the current invention.

A finding of obviousness is proper only when the prior art contains a suggestion or teaching of the claimed invention. Here, the Kita *et al.* does not contain a suggestion of the current invention. It is only the applicants' disclosure that provides such a teaching, and the applicant's disclosure

cannot be used to reconstruct the prior art for a rejection under §103. This was specifically recognized by the CCPA in *In re Sponnoble*, 56 CCPA 823, 160 USPQ 237, 243 (1969):

The Court must be ever alert not to read obviousness into an invention on the basis of the applicant's own statements; that is we must review the prior art without reading into that art appellant's teachings. *In re Murray*, 46 CCPA 905, 268 F.2d 226, 112 USPQ 364 (1959); *In re Sprock*, 49 CCPA 1039, 301 F.2d 686, 133 USPQ 360 (1962). The issue, then, is whether the teachings of the prior art would, in and of themselves and without the benefits of appellant's disclosure, make the invention as a whole, obvious. *In re Leonor*, 55 CCPA 1198, 395 F.2d 801, 158 USPQ 20 (1968). (Emphasis in original)

The mere fact that the purported prior art could have been modified or applied in a manner to yield the applicant's invention would not have made the modification or application obvious unless the prior art suggested the desirability of the modification. *In re Gordon*, 221 USPQ 1125, 1127 (Fed. Cir. 1984). Moreover, as expressed by the CAFC, to support a §103 rejection, "[b]oth the suggestion and the expectation of success must be founded in the prior art" *In re Dow Chemical Co.*, *supra* at 1531. One finds neither in *Kita et al.* in support of a §103 rejection.

Please note that the *Kita et al.* reference teaches that using a greater amount of the FB than its upper limit (i.e., 9.7:93.45) can cause the properties of the electrolytic battery cell to fall (Paragraph 11). On the contrary, practice of the subject invention produces certain highly-desirable, and unexpected, results (i.e., better performance at a low temperature, larger storage at a high-temperature and a larger initial capacitance) by using a relatively large amount of FB in the electrolyte solution. Therefore, the *Kita et al.* reference actually "teaches away" from the claimed invention.

In addition, the purpose or effect of the *Kita et al.* reference is to achieve a lower deterioration in load characteristics of an organic electrolyte secondary battery with increases in charge/discharge cycles.

The Merck reference (or the Hamamoto *et al.* references) does not cure the aforementioned defects of the *Kita et al.* reference.

Therefore, in view of the teachings of the cited references, a person skilled in the art would not have been motivated to increase the amount of FB used in the subject invention with an

expectation of achieving the highly-desirable and unexpected results of the claimed invention. Therefore, the applicants respectfully request reconsideration of the rejection of claims 5 and 6. In addition, claims 8 and 9 have been added to further reflect the high volumetric percentages of fluorobenzenes the present invention utilizes.

The applicants respectfully request reconsideration and withdrawal of the rejection set forth under U.S.C. §103(a).

In view of the foregoing remarks and the amendment above, the applicant believes that the currently pending claims are in condition for allowance, and such action is respectfully requested.

The Commissioner is hereby authorized to charge any fees under 37 CFR §§1.16 or 1.17 as required by this paper to Deposit Account No. 19-0065.

The applicant also invites the Examiner to call the undersigned if clarification is needed on any of this response, or if the Examiner believes a telephone interview would expedite the prosecution of the subject application to completion.

Respectfully submitted,



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Attachment: Translation of Priority Document

【Document Name】 Application

【Kind of Case】 Patent

【Receiver】 The Commissioner of the Korean Intellectual Property Office

【Submitting Date】 July 1, 1999

【Title of Invention】 NON-AQUEOUS ELECTROLYTE COMPOSITION FOR
BATTERIES

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【Applicant Code】 1-1998-001808-7

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【Request for Examination】 No

【Purpose】 I/We apply and request examination for the above under the Articles 42
and 60 of the Korean Patent Law.

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【Commission】

【Basic Filing Fee】	18ages	₩ 29,000
【Additional Filing Fee】	0	₩ 0
【Fee for Priority Claims】	0 case	₩ 0
【Fee for Request for Examination】	0claims	₩ 0

【Total】

₩29,000

【Document Attached】 1. Abstract Specification(Drawings)-1

[Abstract]

Disclosed is a non-aqueous electrolyte composition for batteries, which is composed of a mixture of a fluorobenzene component and a carbonic acid ester component in which the volume ratio of the fluorobenzene component to the carbonic acid ester component ranges from 50:50 to 5:95. The non-aqueous electrolyte composition has a significant advantage over electrolyte compositions employing carbonic acid ester solvents only, in terms of low temperature performance, cell life, and high-temperature dischargeability.

[Specification]**[Title of the Invention]****NON-AQUEOUS ELECTROLYTE COMPOSITION FOR BATTERIES**5 **[Detailed Description of the Invention]****[Objective of the Invention]****[Technical field to which the Invention is pertain and the prior art in the field]**

The present invention relates, in general, to non-aqueous electrolyte compositions for secondary lithium cells and, more particularly, to non-aqueous
10 electrolyte compositions which allow the cells to be greatly improved in low temperature performance, cell life, and high-temperature dischargeability.

Small, slim lithium ion batteries, which are prevalent for use in laptop computers, palmtop computers, camcorders, cellular phones, etc., usually adopt lithium metal-mixed oxides for active cathode materials, carbonaceous materials or metal
15 lithium for active anode materials, and solutions of lithium salts in organic solvents for electrolytes. Conventionally, the organic solvents used for the electrolytes for secondary lithium cells are mixtures of at least two species selected from ethylene carbonate (EC), propylene carbonate (PC), dimethyl carbonate (DMC), diethyl carbonate (DEC), dipropyl carbonate (DPC), ethylmethyl carbonate (EMC),
20 methylpropyl carbonate (MPC), ethylpropyl carbonate(EPC), etc. while a representative example of the lithium salts used is LiPF_6 .

In recent, the improvement in performance of lithium secondary cells has usually been achieved by selecting appropriate combinations of carbonic acid ester-based solvents, by controlling composition ratios between the solvents used, and/or by
25 recruiting certain additives. In addition, active research has been directed to the development of novel solvents, besides carbonic acid ester-based solvents, in order to improve the properties of electrolytes. For instance, Japanese Pat. Laid-Open Publication No. Heisei 8-287950 discloses a method of improving low temperature performance of cells by use of a solvent in which a fluorine-substituted cyclic carbonate

compound and a carbonate compound are mixed at a volume ratio of 30:70. Japanese Pat. Laid-Open Publication No. Heisei 8-96850 introduces as a solvent a mixture of 20-60 % of vinylene carbonate and a linear carbonate compound so as to improve the cycle life and energy density of a cell. The cycle life of a cell is also extended by use of a solvent comprising butylene carbonate and linear carbonate, according to the disclosure of Japanese Laid-Open Publication No. Heisei 7-326358. U.S. Pat. No. 5,192,629 discloses that, even upon over-charging to the extent of 4.5 V or more, a solvent, in which dimethyl carbonate and ethylene carbonate are mixed at a ratio ranging from 95/5 to 20/80 weight %, is useful to inhibit the electrolyte decomposition owing to oxidation, thereby extending the cycle life of the cell.

Because great differences in cell performance occur depending on kinds of the solvents selected from carbonic acid ester compounds and the mixture ratios of solvents, it is quite difficult to select appropriate solvents and their ratios. Further, vinylene carbonate and butylene carbonate are expensive and thus, economically unfavorable. When certain compounds are used to enhance the performance of cells, they can ameliorate only some properties of cells and may deleteriously affect other properties. For example, an electrolyte composition consisting of dimethyl carbonate and ethylene carbonate gives a contribution to the prolongation of the cycle life of the cell, but deteriorates low temperature performance.

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[Technical tasks to be solved by the Invention]

It is an object of the present invention to overcome the above problems encountered in prior arts and to provide a non-aqueous electrolyte for lithium secondary cells, which brings about an improvement in the low temperature performance, high temperature storage, initial capacitance, and cycle life properties of lithium secondary cells.

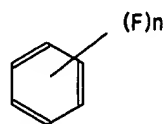
25

This object can be achieved by a non-aqueous electrolyte composition for lithium secondary cells, comprising a solution containing fluorene compound and carbonic acid ester.

[Constitution and operation of the invention]

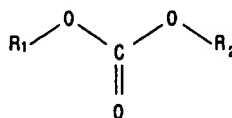
In accordance with the present invention, there is provided a non-aqueous electrolyte composition for lithium secondary cells, comprising a lithium salt dissolved in an organic solvent system composed of a fluorobenzene component (FB) and a carbonic acid ester component (CE), wherein the solvent components are present in a volume percent ratio range from 50 FB : 50 CE to 5 FB : 95 CE, said fluorobenzene component being one or more compounds represented by the following general formula 1 :

[Formula 1]



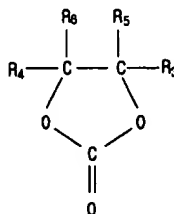
wherein F represents a fluorine element and n is an integer of 1-6; said carbonic acid ester component being one or more compounds represented by the following general formulas 2 and 3:

[Formula 2]



wherein R₁ and R₂, which may be the same or different, each represents an alkyl radical containing 1-4 carbon atoms.

[Formula 3]



wherein R_3 , R_4 , R_5 and R_6 , which may be the same or different, each represents a hydrogen atom or an alkyl radical containing 1-4 carbon atoms.

The present invention pertains to a mixture of fluorobenzene and carbonic acid ester, useful for a non-aqueous electrolyte for lithium cells.

Examples of the fluorobenzene compound represented by the general formula 1 include fluorobenzene, difluorobenzene, trifluorobenzene, tetrafluorobenzene, pentafluorobenzene and hexafluorobenzene. These compounds may be used alone or in combination. This fluorobenzene solvent component appropriately coordinates lithium ions to effect high conductivity at low temperatures. In addition, the fluorobenzene solvent is 4.5 V or higher in linear sweep voltametry (LSV), showing resistance to the electrolyte decomposition reaction at a cathode upon charging. Consequently, the fluorobenzene solvent improves not only low temperature properties, but also life performance of cells.

In the present invention, carbonic acid ester which composes the organic solvent for the electrolyte, is a cyclic carbonate of the general formula 3, a chain carbonate of the general formula 2, or a mixture thereof. The cyclic carbonate of the general formula 3 is exemplified by ethylene carbonate, propylene carbonate, and butylene carbonate. As for the chain carbonate of the general formula 2, its examples include dimethyl carbonate, diethyl carbonate, dipropyl carbonate, methylpropyl carbonate, ethylmethyl carbonate, ethylpropyl carbonate, etc. The above-exemplified carbonate compounds may be used alone or in combination.

In the solvent mixture of fluorobenzene and carbonic acid ester, the fluorobenzene compound of the general formula 1 preferably amounts 5 to 50 % by volume while the carbonic acid ester of the general formula 2 and/or 3 ranges from 50 to 95 % by volume, correspondingly. For example, when the fluorobenzene compound of the general formula 1 is over 50 % by volume, phase separation of the solvent components used occurs, along with the solidification of the lithium salt, at low temperatures, deteriorating the low temperature performance and the life properties of

the cells. On the other hand, if the fluorobenzene compound is used at an amount of less than 5 % by volume, almost no addition effects are obtained on cell performance. Under this condition, the preferable volume ratio of the compound of the general formula 1 to the compound of the general formula 2 is in a range of 2:1 - 1:10. This volume range is also true of the ratio of the compound of the general formula 1 to the compound of the general formula 3.

Useful as the lithium salt are one or more compounds selected from LiPF_6 , LiClO_4 , LiCF_3SO_3 , LiAsF_6 , and LiBF_4 . The salt ranges, in concentration, from 0.7 to 2.0 M. For example, when the salt has a concentration of less than 0.7 M, the electrolyte is too low in electroconductivity to function well. On the other hand, if the concentration of the electrolyte exceeds 2.0 M, an increase is brought about in the viscosity at low temperatures, giving rise to a decrease in the mobility of lithium ions and thus, in the low temperature performance of the cell.

A better understanding of the present invention may be obtained in light of the following examples which are set forth to illustrate, but are not to be construed to limit the present invention.

[Example 1]

In Example 1, ethylene carbonate (EC), dimethyl carbonate (DMC) and fluorobenzene (FB) were mixed at a volume ratio of 1:1:1 while LiPF_6 was dissolved as a solute. The electrolyte thus obtained was used to prepared a 18650 cylindrical cell, after which an examination was made of the discharge/charge capacity ratio (%) after a first charge/discharge cycle, the discharge/nominal capacity ratio (%) at -20 °C, and the discharge/nominal capacity ratio (%) after 150 cycles to evaluate the life performance of the cell. The results are given in Table 1, below. In the cell, carbon black was used as an active material for the anode, polyvinylidene fluoride (PVDF) as a binder, LiCoO_2 as an active material for the cathode, and acetylene black as a current collector.

[Example 2]

The same procedure as in Example 1 was repeated except the ratio of Eethylene carbonate(EC):dimethylcarbonate:fluorobenzene(FB) being 4:4:1. The properties of the cells thus prepared were measured and are given in Table 1.

5 **[Example 3]**

The same procedure as in Example 1 was repeated except the ratio of Eethylene carbonate(EC):dimethylcarbonate:fluorobenzene(FB) being 2:2:1. The properties of the cells thus prepared were measured and are given in Table 1.

10 **[Example 4]**

The same procedure as in Example 1 was repeated except the ratio of Eethylene carbonate(EC):dimethylcarbonate:fluorobenzene(FB) being 2: 1: 2. The properties of the cells thus prepared were measured and are given in Table 1.

15 **[Example 5]**

The same procedure as in Example 1 was repeated except the ratio of Eethylene carbonate(EC):dimethylcarbonate:fluorobenzene(FB) being 2: 1: 3. The properties of the cells thus prepared were measured and are given in Table 1.

20 **[Example 6]**

The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):diethylcarbonate(DEC): fluorobenzene (FB) was 3: 3: 1: 1 and test for dischargeability after storage at high temperature(60 °C) was conducted and the result was shown in Table 2.

25 **[Example 7]**

The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):diethylcarbonate(DEC):1,2difluorob enzene(1,2-DFB) was 3: 3: 1:1 and test for dischargeability after storage at high temperature(60 °C) was conducted and the result was shown in Table 2.

[Example 8]

The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):diethylcarbonate(DEC):1,3difluorob
enzene(1,3-DFB) was 3: 3: 1:1 and test for dischargeability after storage at high
5 temperature(60°C) was conducted and the result was shown in Table 2.

[Example 9]

The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):diethylcarbonate(DEC):1,4difluorob
10 enzene(1,4-DFB) was 3: 3: 1:1 and a test for dischargeability after storage at high
temperature(60°C) was conducted and the result was shown in Table 2.

[Example 10]

The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):diethylcarbonate(DEC):1,2,4trifluor
15 obenzene(1,2,4-TFB) was 3: 3: 1:1 and test for dischargeability after storage at high
temperature(60°C) was conducted and the result was shown in Table 2.

[Example 11]

20 The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):propylenecarbonate(PC):
fluorobenzene(FB) was 4: 4: 0.5:1.5- and test for standard capacity was conducted and
the result was shown in Table 1.

[Example 12]

25 The same procedure as in Example 1 was repeated except that the ratio of Eethylenecarbonate(EC):dimethylcarbonate(DMC):propylenecarbonate(PC):
fluorobenzene(FB) was 4: 3.5: 1:1.5 and test for standard capacity was conducted and

the result was shown in Table 1.

[Example 13]

The same procedure as in Example 1 was repeated except that the ratio of
5 Eethylenecarbonate(EC):dimethylcarbonate(DMC):propylenecarbonate(PC):
fluorobenzene(FB) was 3.5: 4: 0.5:2.0 and test for standard capacity was conducted and
the result was shown in Table 1.

[Example 14]

10 The same procedure as in Example 1 was repeated except that the ratio of
Eethylenecarbonate(EC):dimethylcarbonate(DMC):propylenecarbonate(PC):
fluorobenzene(FB) was 3.5: 3.5: 1:2 and test for standard capacity was conducted and
the result was shown in Table 1.

15 **[Example 15]**

The same procedure as in Example 1 was repeated except that the ratio of
Eethylenecarbonate(EC):dimethylcarbonate(DMC):propylenecarbonate(PC):
fluorobenzene(FB) was 3: 2.5: 0.5:4 and test for standard capacity was conducted and
the result was shown in Table 1.

20

[Comparative Example 1]

A cell was prepared in a similar manner to that of Example 1, except that a
mixture of 1:1 ethylene carbonate (EC):dimethyl carbonate (DMC) was used as a
solvent for the electrolyte. The evaluation of the properties of the cell is shown in

25 Table 2

[Comparative Example 2]

A cell was prepared in a similar manner to that of Example 1, except that a
mixture of 1:1 ethylene carbonate (EC):dimethyl carbonate (DMC) was used as a

solvent for the electrolyte and a test for dischargeability after storage at high temperature(60°C) was conducted. The evaluation of the properties of the cell is shown in Table 2.

5 **[Comparative Example 3]**

A cell was prepared in a similar manner to that of Example 1, except that a mixture of 3:3:1 ethylene carbonate (EC):dimethyl carbonate (DMC): diethyl carbonate (DEC) was used as a solvent for the electrolyte and a test for dischargeability after storage at high temperature(60°C) was conducted. The evaluation of the properties of
10 the cell is shown in Table 2.

[Comparative Example 4]

A cell was prepared in a similar manner to that of Example 1, except that a mixture of 4.5:4.5:1 ethylene carbonate (EC):dimethyl carbonate (DMC): propylene
15 carbonate (PC) was used as a solvent for the electrolyte and a test for standard capacity was conducted. The evaluation of the properties of the cell is shown in Table 3.

[Comparative Example 5]

A cell was prepared in a similar manner to that of Example 1, except that a
20 mixture of 4.5:4.5:1 ethylene carbonate (EC):diethyl carbonate (DEC): propylene carbonate (PC) was used as a solvent for the electrolyte and a test for dischargeability after storage at high temperature(60°C) was conducted. The evaluation of the properties of the cell is shown in Table 3.

25 **[Comparative Example 6]**

A cell was prepared in a similar manner to that of Example 1, except that a mixture of 4.5:4.5:1 ethylene carbonate (EC):ethylmethyl carbonate (EMC): propylene carbonate (PC) was used as a solvent for the electrolyte and a test for dischargeability

after storage at high temperature(60°C) was conducted. The evaluation of the properties of the cell is shown in Table 3.

[Comparative Example 7]

- 5 A cell was prepared in a similar manner to that of Example 1, except that a mixture of 3:3:1:1 ethylene carbonate (EC):dimethyl carbonate (DMC): diethyl carbonate (DEC): α,α,α -trifluorotoluene (TFT) was used as a solvent for the electrolyte and a test for dischargeability after storage at high temperature(60°C) was conducted. The evaluation of the properties of the cell is shown in Table.3.

10

[TABLE 1]

Nos. of Exmpl.	Vol. Ratio of Solvents	% Discharge/ Charge Capacity after 1st cycle	% Discharge/ Nominal Capacity at -20 °C	% Discharge/ Nominal Capacity after 150 Cycles
1	EC:DMC:FB =1:1:1	93.8	83.4	85.5
2	EC:DMC:FB =4:4:1	93.4	74.3	84.3
3	EC:DMC:FB =2:2:1	93.6	82.6	85.2
4	EC:DMC:FB =2:1:2	93.9	75.5	83.0

$\frac{1}{9} : \frac{8}{9}$
 $\frac{1}{5} : \frac{4}{5}$
 $\frac{2}{5} : \frac{3}{5}$

2:1

5	EC:DMC:FB =1:1:2	94.1	60.8	81.3
C. 1	EC:DMC=1:1	93.4	23.7	84.3

TABLE 2

Nos. of Exmpl	Vol. Ratio of Solvents	% Dischargeability after Storage at High Temp.	% Discharge/ Nominal Capacity at -20 °C	% Discharge/ Nominal Capacity after 300 Cycles
6	EC:DMC:DEC:FB =3:3:1:1	89.2	84.5	84.2
7	EC:DMC:DEC:1,2-DFB =3:3:1:1	89.0	84.1	81.0
8	EC:DMC:DEC:1,3-DFB =3:3:1:1	89.2	83.5	78.5
9	EC:DMC:DEC:1,4DFB =3:3:1:1	89.2	84.2	80.3
10	EC:DMC:DEC:1,2,4-TFB =3:3:1:1	88.3	81.3	77.5

C.2	EC:DMC=1:1	87.5	28.7	81.5
C.3	EC:DMC:DEC=3:3:1	85.5	83.1	76.1

Note : EC=ethylene carbonate, DMC=dimethyl carbonate

DEC=diethyl carbonate, FB=fluorobenzene

DFB=difluorobenzene, TFB=trifluorobenzene

5

TABLE 3

Nos. of Exmpl.	Vol. Ratio of Solvents	% Standard/ Nominal Capacity	% Discharge/ Nominal Capacity at -20 °C	% Discharge/ Nominal Capacity after 300 Cycles
11	EC:DMC:PC:FB =4:4:0.5:1.5	100.5	84.3	84.5
12	EC:DMC:PC:FB =4:3.5:1:1.5	99.6	80.9	85.5
13	EC:DMC:PC:FB =3.5:4:0.5:2	100.7	85	88.0
14	EC:DMC:PC:FB =3.5:3.5:1:2	100.1	82.2	87.8

15	EC:DMC:PC:FB =3:2.5:0.5:4	100.5	85.5	81
C.4	EC:DMC:PC =4.5:4.5:1	97.5	65.1	80.5
C.5	EC:DMC:PC =4,5:4.5:1	95.3	47.3	72.1
C.6	EC:EMC:PC =4.5:4.5:1	96.5	67.4	74.0
C.7	EC:DMC:PC:TFT =3:3:1:1	95.5	75.4	35 (after 200 cycles)

Note : EC=ethylene carbonate, DMC=dimethyl carbonate
 PC=propylene carbonate, EMC=ethylmethyl carbonate
 FB=fluorobenzene, TFT= $\alpha\alpha\alpha$ -fluorotoluene

5 Assay for Physical Properties

* Low Temperature Dischargeability (%Discharge capacity/nominal capacity at -20 °C): when a cell was charged at 0.2 C to the potential of 4.1 V, allowed to stand at -20 °C for 16 hours, and discharged at 0.2 C to the potential of 2.75 V, the capacity decrease was measured.

* Cycle Life (%Discharge capacity/nominal capacity after cycles): after 150-300 cycles, each cycle consisting of charging up to 4.1 V and discharging down to 2.75 V at 1 C, a cell was measured for the decrease of cell capacity.

* High Temperature Storage Test (% Discharge capacity after storage at 60 °C):
a cell was charged at 0.5 C to 4.1 V, allowed to stand at 60 °C for 30 days, and
discharged at 0.2 C to 2.75 V, followed by measuring the decrease of cell capacity
(discharge capacity/nominal capacity).

5 * Standard Capacity: cell capacity shown when a cell was discharged at 1 C to
2.75 V after being charged at 0.5 C to 4.1 V.

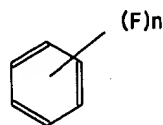
As described hereinbefore, the non-aqueous electrolyte composition of the
present invention has a significant advantage over conventional electrolyte
10 compositions employing carbonic acid ester solvents only, in terms of low temperature
performance, cell life, and high-temperature dischargeability.

The present invention has been described in an illustrative manner, and it is to be
understood that the terminology used is intended to be in the nature of description rather
15 than of limitation. Many modifications and variations of the present invention are
possible in light of the above teachings. Therefore, it is to be understood that within
the scope of the appended claims, the invention may be practiced otherwise than as
specifically described.

CLAIMS

1. A non-aqueous electrolyte composition for lithium secondary cells, comprising a lithium salt dissolved in an organic solvent system composed of a fluorobenzene component (FB) and a carbonic acid ester component (CE), wherein
5 the solvent components are present in a volume percent ratio range from 50 FB :50 CE to 5 FB : 95 CE, said fluorobenzene component being one or more compounds represented by the following general formula 1:

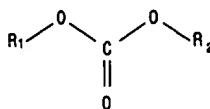
[Formula 1]



10

wherein F represents a fluorine element and n is an integer of 1-6; said carbonic acid ester component being one or more compounds represented by the following general formulas 2 and 3:

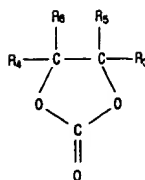
[Formula 2]



15

wherein R₁ and R₂, which may be the same or different, each represents an alkyl radical containing 1-4 carbon atoms.

[Formula 3]



wherein R₃, R₄, R₅ and R₆, which may be the same or different, each represents a hydrogen atom or an alkyl radical containing 1-4 carbon atoms.

5 2. A non-aqueous electrolyte composition as set forth in claim 1, wherein said fluorobenzene component of the general formula 1 is a mixture of fluorobenzene and difluorobenzene.

3. A non-aqueous electrolyte composition as set forth in claim 1, wherein said
 10 lithium salt is selected from the group consisting of LiPF₆, LiClO₄, LiAsF₆, LiBF₄, LiCF₃SO₃ and mixtures thereof and used at a concentration of 0.7-2.0 M.

4. A non-aqueous electrolyte composition as set forth in claim 1, wherein said carbonic acid ester component is selected from the group consisting of ethylene
 15 carbonate, propylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, dipropyl carbonate, ethylmethyl carbonate, methylpropyl carbonate, ethylpropyl carbonate and mixtures thereof.

5. A non-aqueous electrolyte composition as set forth in claim 1, wherein said
 20 organic solvent system ranges, in the volume ratio of the solvent component of the

general formula 1 to the solvent component of the general formula 2, from 2/1 to 1/10.

6. A non-aqueous electrolyte composition as set forth in claim 1, wherein said organic solvent system ranges, in the volume ratio of the solvent component of the
- 5 general formula 1 to the solvent component of the general formula 3, from 2/1 to 1/10